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Device for Damping Pressure Surges

The invention relates to a device for damping pressure surges in a fluid, the device having a housing and a piston displaceable longitudinally against the pretensioning force of a spring-type accumulator.

Such devices include the so-called hydraulic accumulators, one of the main functions of which is to receive specified volumes of a pressurized fluid of a hydraulic system and to return them to the system as required. Since the fluid is pressurized, hydraulic accumulators are treated as pressure vessels and must be designed to withstand the maximum operating pressure as determined by the approval standard. For volume equalization in the hydraulic accumulator and as a result the associated storage of energy, the pressurized fluid in the hydraulic accumulator is subjected to the force exerted by a weight, spring, or gas. Equilibrium always prevails between the pressure of the pressurized fluid and the opposing pressure generated by the weight of the spring or by the gas. In most hydraulic systems use is made of hydropneumatic accumulators, that is, ones subjected to the action of a gas and having a separating element, a distinction being made between bladder, piston-type, and diaphragm accumulators.

These hydropneumatic accumulators perform a wide variety of functions in a hydraulic system. For example, in addition to performing the energy storage function referred to they may also be called upon to contribute to absorption of mechanical shocks and to surge damping in hydraulic systems. Pulsations occur in the flow volume especially when hydraulic pumps such as positive-displacement pumps are employed. Such pulsations cause vibrations as well as noise, and this may result in damage to the hydraulic system as a whole.

The hydraulic pumps in question, positive-displacement pumps in particular, are also employed in so-called common-rail technology in the area of diesel engines. Recent third-generation developments add piezo technology for injection systems for diesel fuel. The recently developed piezo inline injectors for the third common-rail generation (cf. VDI-Nachrichten [Association of German Engineers - News], No. 33, August 15, 2003) use piezo actor modules, which act by way of coupler modules on switching valves and the latter in turn act on an injector module of the fuel injection system, the outstanding hydraulic rapidity of the system resulting from the high degree of integration of the inline injector, that is, from the nearness of the piezo package to the valve needle in the tip of the injector. In comparison to the previous generation the mass moved was reduced in the new systems from 16 g to 4 g, the mass moved being understood to mean the mass of the valve needle and the fuel with which the control space is filled. The respective technical configuration requires very high system pressures, ones reaching the order of magnitude of 2200 bar. The respective system pressure is to be built up by the hydraulic pump indicated, in particular a positive-displacement pump, the build-up being attended by the disadvantages described of pressure and pulsation surges. If the pressure surges are transmitted to the injector system, this may result in critical states of the system and in failure of the piezo injector system with the injection system. If, as is known in the state of the art (see DE 195 39 885 A1), conventional hydraulic accumulators with separating elements (pistons) are included in the diesel fluid system as outlined in the foregoing, they nevertheless encounter their limits in view of the high system pressures indicated of up to 2200 bar.

DE 101 48 220 A1 discloses another device for damping pressure pulsations in a fluid system, especially in a fluid system of an internal combustion engine. The device disclosed comprises a housing in which at least one operating space is present. This space is connected to the fluid system and is limited in area by at least one movable wall element in the form of a metal diaphragm which is mounted on the edge side in the housing so as to be stationary. This wall element is functionally connected to a first spring unit and, in order to provide the possibility of smoothing out pressure pulsations in the fluid system even with variable pressure present, provision is made such that the device comprises at least a second movable wall element which delimits a second operating space and also consists of a metal diaphragm fastened on the edge side in the housing. The first spring unit is mounted between the two wall elements in the form of diaphragms and is functionally connected to both. A throttle unit is also provided by way of which the second operating space is connected to the fluid system. It is true that pressure pulsations in a fluid system may be reliably and efficiently smoothed out with different pressure levels present. However, because of the stationary clamping of the wall elements (diaphragms) their movability is restricted, so that functional safety in operation may be endangered at high pressures and correspondingly large pulsation and pressure surges.

On the basis of this prior art the object of the invention is to make available a device for damping pressure surges making it possible, even with very high system pressures produced by a hydraulic pump, a diesel fuel pump in particular, ones as high as 2200 bar, to dampen and/or smooth out such pressure surges so that there is no harmful introduction of power into a piezo injector system of common-rail technology. The object as thus formulated is attained by a device having the characteristics specified in patent claim 1 in its entirety.

In that, as specified in the characterizing part of claim 1, the piston operates in conjunction with another piston which is be guided so as to be displaceable longitudinally in a connecting piece of the housing, and in that in operation of the device the piston exerts a

compressive force on the other piston in every displaced position of the latter, very high-frequency pressure surges may be controlled in the diesel fuel system yet operation remains safe, even if due to the hydraulic pump in the form of the diesel fuel pump very high system pressures of up to 2200 bar and higher are produced. As a result of mechanical uncoupling of the two pistons in question and the constant application of the compressive force by one piston on the other, it is made certain that any pressure surges introduced can be intercepted and controlled and in particular that uncoupling of the pistons ensures that any leakage accompanied by leakage flows, are kept small or controlled so that operational failures are prevented in the system as a whole. Provision preferably is made such that one piston is of a diameter several times greater than the diameter of the other piston, and it has been found that an unimpeded actuation process may be achieved with the pistons. Processes of canting of the other piston in the connecting piece of the housing in particular are prevented by separate, independent control of this piston.

In one preferred embodiment of the device claimed for the invention the other piston is configured as a stamp and is controlled by at least one anti-loss device in a through opening in the housing of the connecting piece. Free displaceability of the respective piston between specified displaceability limits in the housing configuration is thereby achieved.

In another preferred configuration of the device claimed for the invention the other piston is machined to the highest degree on the external circumference side, in particular is lapped, so that a metal-sealed gap is obtained at least between parts of the external circumference and the other piston on the inner wall of the opening in the housing. In another configuration of the sealing system in question the other piston may be provided with annular or lubrication grooves on the external circumference side. As a result, despite the high pressures of up to 2200 bar and above in the diesel fluid system reliable sealing of the other piston from the interior of the housing with the first piston is achieved and, especially when annular or lubricating grooves on

the external circumference of the other piston are used, a fluid seal may be built up which works against entry of fluid into the gap in the metal.

If, in another preferred embodiment of the device claimed for the invention, a leakage opening configured in the housing communicates with the fluid space between the pistons, diesel medium which succeeds in penetrating the interior of the housing may nevertheless be transferred free of pressure in the block as a sort of return flow for oil leakage in the direction of the tank or leakage side.

With respect to the very high pressures indicated it has been found to be advantageous to provide as spring-type accumulator at least one helical spring configured as pressure spring and/or a pressure gas. Use of a pure pressure gas may entail the disadvantage that, in view of the very high pressures, a process of liquefaction of the gas will take place in the housing area as a result of compression of the piston first indicated. However, as an alternative or in addition, the system pressures indicated may be reliably controlled by use of a pressure spring as the spring-type accumulator.

Other advantageous embodiments of the device claimed for the invention are specified in the other dependent claims.

The device claimed for the invention will be described below on the basis of an exemplary embodiment with reference to the drawing, in which, in diagrammatic form not drawn to scale, the sole figure illustrates a longitudinal section of the device claimed for the invention for damping pressure surges, with two different cover element embodiments.

The device illustrated in the figure performs the function of damping pressure surges in a fluid, in particular one in the form of diesel fuel, the device having a cylindrical housing 10. The

device also has a piston 14 which may be displaced longitudinally against the initial pretensioning force of a spring-type accumulator 12. The respective piston is configured as a cylindrical contact plate and is guided along its external circumference by a slip and/or sealing ring 16 along the cylindrical interior circumference 18 of the housing 10. The piston 14 accordingly has on its opposite sides two essentially level contact surfaces 20, 22 and for the purpose of guiding the spring-type accumulator 12 the piston 14 is provided on the side facing in this direction with a cylindrical guide surface 22 which also rests against the inner circumference 18 of the housing 10 on the outer circumference side.

The piston 14 operates in conjunction with another piston 24, which other piston 24 may be guided to be longitudinally displaceable in a connecting piece 26 of the housing 10. As the illustration in the figure shows, the piston 14 furthermore operates in the housing by applying the compressive force to the other piston 24, in every displaced operating position, including its front end contact position as shown, in operation or use of the device. The connecting piece 26 narrows in stages toward the free end of the housing 10 and is provided on the outer circumference side with a connecting thread 28 by means of which the housing 10 in the configuration illustrated may be connected to a fluid system such as the diesel supply line for an injector system by the common rail technology. The housing 10 is positioned in a connecting line which leads to a hydraulic pump, a positive-displacement pump in particular, for example, one in the form of a diesel fuel pump or the like. The pressure surges occurring in operation of the diesel fuel pump, which may be considerable, with system pressures of up to 2200 bar or higher, are damped and smoothed out by the device claimed for the invention; even high-frequency fluid surges are to be evened out. In addition, the damping device claimed for the invention is independently effective within prescribed limits even in the event of very high pressure amplitudes.

The respective connecting piece 26 undergoes transition to a bottom 30 of the housing 10, strengthened lengthwise, of the housing 10 and the pistons 14, 24 referred to and the spring-type accumulator 12 are oriented longitudinally toward the longitudinal axis 32 of the housing 10 and connecting piece 26. In addition, the diameter of the piston 14 is several times greater than the diameter of the other piston 24, so that very good impact force is introduced between the other piston 24 and first piston 14, in view of the change in the relationship of diameters.

The other piston 24 is thus configured as a stamp or push rod and is guided in the through opening in the housing 36 of the connecting piece 26 by way of at least one anti-loss device 34 in the form of a retaining ring. The anti-loss device 34 may consist in particular of a retaining ring the front of which seals the housing opening 36 from the exterior and the projecting length of which comes in contact with the front end of the other piston 24 when the latter is in its front limit position. When the other piston 24 is not in operation its length has been determined so that the piston remains at a short axial distance, with slight clearance, from the anti-loss device 34. However, as soon as a specified pressure level has been built up by the fuel, the clearance is eliminated and, when the device is in the respective state of operation or use, the piston 14 applies a compressive force to the other piston 24 in any displaced position of the latter. In order to obtain good sealing, the other piston 24 undergoes the highest degree of precision machining on the external circumference side, in particular is lapped, so that a metal-sealed gap 38 is obtained at least between parts of the external circumference of the other piston 24 and the interior wall of the housing opening 36. The other piston 24 has annular or lubricating grooves 40 for the purpose of further improvement in the sealing system. A labyrinth seal is thus obtained, one which makes it difficult for the diesel fuel to penetrate through the housing opening 36 into the clearance space 42 inside the housing 10 between the contact surface 20 and the facing surface 44 of the bottom 30.

The fluid or clearance space 42 between the pistons 14, 24 communicates with a leakage opening 46 in the form of a bore in the housing 10. Consequently, an intentionally provided gap or leakage flow may be evacuated by way of the sealing system in the form of annular or lubricating grooves 40, the metal gap 38, and the clearance space 42 by way of the leakage opening 46 to the pressure-free leakage or tank side of the overall system. A sealing system 48, such as one in the form of a conventional radial seal ring, is provided as an additional sealing system in the front area of the bottom 30. When the housing 10 has been screwed into place, sealing, especially in the form of the leakage opening 46, from the overall hydraulic or fluid system (diesel line network) may accordingly be effected by way of the connecting piece 26 with its connecting thread 28.

A pressure spring in the form of a helical spring in this instance serves as a spring-type accumulator 12; pressure gas such as gas in the form of nitrogen may be applied in addition to the interior of the housing. The respective pressure spring 12 extends between the piston 14 and a cover element 50 which cover element 50 may be in the form of a retaining plate 52 and which is retained in the housing 10 by safety means, a retaining ring 54 in particular. An alternative embodiment is presented in the figure in square framing and in this instance the cover element 50 consists of a screw cap 56 which may be screwed onto the housing 10 by way of external threading 58 on the external circumference side of such housing 10.

The device claimed for the invention makes certain that any leakage flow which may occur may be reliably controlled and the separate piston configuration of the pistons 14 and 24 ensures that canting does not occur. Pressure surges of very high frequency in particular which affect the stamp-like additional piston 24 may be transmitted at the same frequency as surges to the piston 14, which then effects pulsation damping or smoothing by reacting on the other piston 24. The system illustrated may be applied cost-effectively and by simple production technology with conventional steel materials, on the housing 10 side in particular. The device claimed for

the invention may generally be employed where low volumes under high pressure are to have the level damped or are to be displaced. Because of the surface relationships of the pistons the spring to be employed may be made smaller, since the force required is correspondingly reduced.